Care for Chronic Diseases in Low Income Countries The health system perspective and self-management of diabetes

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Chapter 9. The effect of text messages to support diabetes self-management in developing countries - the TEXT4DSM study

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Abstract

Objective
Mhealth interventions have the potential to facilitate self-management support. The TEXT4DSM study implemented a mobile phone intervention within existing diabetes programmes in three low and middle income countries (DR Congo, Cambodia and the Philippines).

Research Design and Methods
Three sub-studies with a similar randomised controlled trial design were carried out in which 480 adults with diabetes were included in each country, receiving routine care or routine care complemented with text message self-management support. The primary outcome is the difference in proportion of people with a well-controlled diabetes after 2 years.

Results
Baseline and 2-year HbA1c measurements ware available for 781 people. After 2 years, the proportion of people with a controlled HbA1C was 2.8% higher in the intervention than in the control group (difference not- statistically significant). In the logistic regression model, the odds ratio for having a controlled diabetes after the intervention is 1.1, corrected for baseline HbA1c level, for sex, for being on insulin treatment, and adjusted for the routine programme. The general tendencies in HbA1c dynamics over time were different between programmes, with the proportion of people having controlled diabetes increasing in DR Congo for both intervention and control groups, and decreasing for both in Cambodia.

Conclusions
This study does not show an additional effect of a text message self-management support intervention on diabetes control after 2 years.

Introduction

There are global attempts to increase access to diabetes care in low-income countries (LIC), and there is also recognition that the quality of diabetes care in LIC is important and that it should comprise dimensions of chronic care models, including self-management. Self-management is recognized as an essential component of diabetes care (1-3). Diabetes Self-Management Education (DSME) and Diabetes Self-Management Support (DSMS – activities to assist people in sustaining self-management behaviours) are complementary elements of programmes to assist patients in developing self-management capacity, which have proven beneficial (4,5). Yet to implement these chronic care elements into health systems in LIC is a big challenge. Some initiatives have been described (6-8), most of which focused on education, fewer on broader support, such as realizing behaviour change or developing coping skills.

In addition to face-to-face contacts, diabetes self-management support interventions use a mix of tools to reach patients, such as brochures, phones calls and websites. Mhealth interventions have the potential to facilitate self-management education and support (9). Its application in LIC has been limited and its effects on diabetes control mixed (10-13). Most studies are small and were of limited quality, for instance because they lack a theory underlying the intervention. This dearth of evidence hinders a better understanding of the added value of mhealth interventions in self-management support and diabetes care programmes in LIC.

The TEXT4DSM study was designed to address this gap. We implemented a mobile phone DSMS intervention embedded in three existing diabetes programmes, in DR Congo, Cambodia and the Philippines (14). The overall aim of the study was to evaluate the effectiveness of the intervention in each programme, and to assess the processes and the contextual factors that influenced the implementation. One previous report analysed the health care context in the three settings, another one analysed the process of implementation (15,16). This paper reports on the effect of the intervention after 2 years on health outcomes and on intermediate outcomes. The primary research question was: has the additional DSMS intervention led to more people having a HbA1c level below 7.0% (53 mmol/mol) at the end of the study, compared to people who participate in the routine programme?

Methods

Study design

The study consisted of three sub-studies with a similar design in three countries: a two-arm Randomised Controlled Trial (RCT), in 480 adults with diabetes (type 2 or 1) participating in an existing DSME programme in each country, randomly allocated to either self-management education as provided by the existing programme (DSME-only) or to self-management education plus a mobile phone self-management support intervention (DSME+DSMS) (14). Participants in both arms were assessed at baseline, one year and two years after inclusion. The primary outcome measure is the difference in percentage of people with a well-controlled HbA1c level after 2 years between the intervention and the control group. Diabetes is a progressive disease and it is therefore likely that the proportion of people with a well-controlled HbA1C will change over time for both groups. In order to capture this dynamic and to see how the DSMS intervention would affect the dynamic, we added a secondary outcome measure: the difference in change of HbA1c levels after 2 years , between the intervention and control group. (Figure of Study Design added as web annex, figure 1)

Study context and subjects

The studies took place within the 'Kin-réseau' programme in DR Congo (DRC), 'MoPoTsyo' in Cambodia and the First Line Diabetes Care (FildCare) project in the Philippines. Kin-réseau is a 40-year old network of faith-based primary care facilities in Kinshasa, which deliver diabetes care and education as part of their basic package. MoPoTsyo is a community-based peer

educator network supported by an NGO, in which patients are recruited trough community screening, receive biomedical care facilitated by the NGO and self-management support in groups facilitated by a peer educator. In the FiLDCare project, trained health workers and a Barangay or Community Health Workers (CHW) provide diabetes education and support to diabetes patients. Subjects were eligible for participation if they were >= 18 years old, had been diagnosed with diabetes, were registered in a centre participating in the study and had received at least one session in the usual care programme in the preceding year.

Routine programme: biomedical care and DSME

The biomedical care existed of consultations with a doctor (from 2-montly in the Kin-réseau to half-yearly in MoPoTsyo), which included monitoring of glycaemia and risk factors and the prescription of medication. Educators provided ongoing DSME. In Kin-réseau, DSME was scheduled weekly by a nurse to groups of around 100 patients, in MoPoTsyo, it was scheduled monthly by peer educators to groups of usually 60 patients, and in FiLDCare on a regular but not fixed time basis, to groups of around 8 patients (15). Educators use posters and booklets to convey their message, both in group sessions and individual contacts. In preparation of the study, the DSME programme was optimised to a minimum standard comprising messages about nine dimensions of diabetes self-management: 1) explanation of diabetes disease processes, 2) healthy eating, 3) physical activity, 4) monitoring, 5) medications, 6) foot care, 7) tobacco and alcohol control, 8) patient-held records, and 9) problem solving by and empowerment of patients (17).

The additional DSMS intervention

Patients in the intervention group received additional DSMS through automated Short Messages Services (SMS) on a mobile phone, which they were provided with at inclusion in the study. Participants allocated to the control group also received a mobile phone, but they did not receive project-initiated SMS messages . Contracts were negotiated with a national phone provider for buying new phones and SIM cards for all participants and for sending messages. The SMS were sent using the open access software Frontline (18) in Kin-réseau and MoPoTsyo and the internet-based application 'Chikka' in FiLDCare (19). Messages for the DSMS were developed following the nine dimensions of DSME. A protocol included a guideline about the content of messages and the underlying principles of the behaviour theory of change. Each programme developed their own protocol on the development and sending of DSMS, taking into account the local differences in the organisation and context. These protocols specified messages to be sent 5 times per week in Kin-réseau, 6 times per week in MoPoTsyo and 2 times per week in FiLDCare.

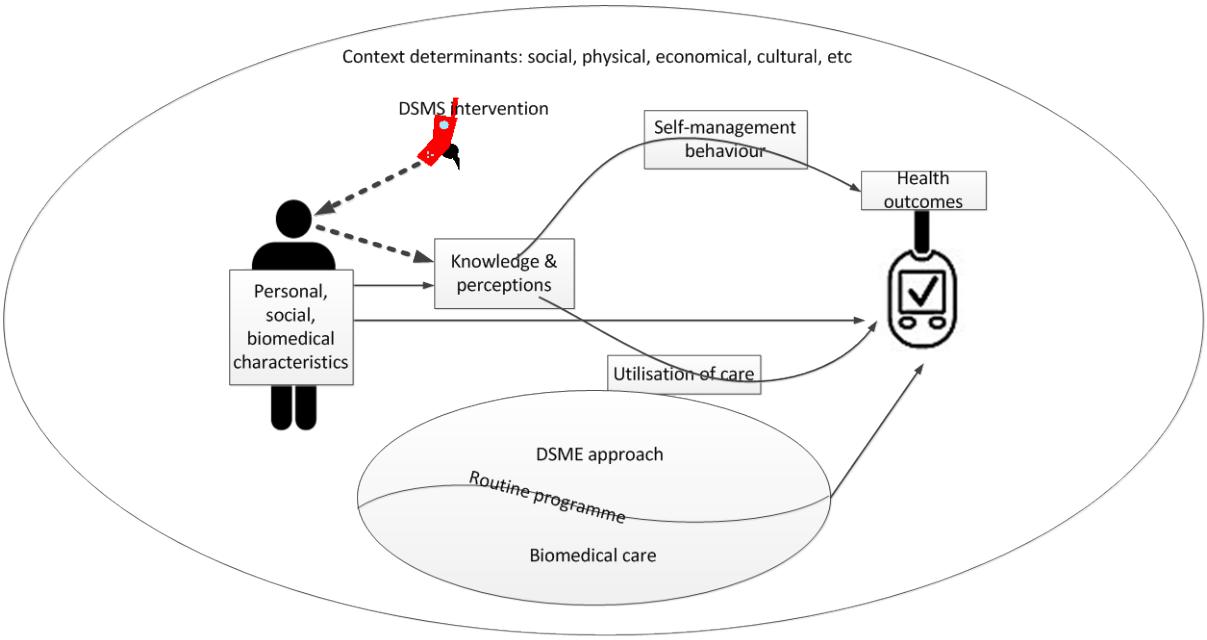
The implementation manager was responsible for sending the SMS and to follow-up problems with coverage of the intervention, which related to technological barriers (with the phone, the subscription, or the network), contextual changes (new phone providers and people switching phone numbers) and participant behaviour (people not reading their messages). Subscriptions were renewed, phone numbers adjusted and, where no other option was possible, new phones were provided. In MoPoTsyo, the manager implemented two innovations in the intervention in the 2nd year: the use of voice messaging instead of SMS, due to limitations in using Khmer script, and the targeting of one quarter of all messages to specific groups, for instance to obese patients. The 1-year process evaluation showed that the average number of SMS sent out to participants was 15.7 per month in Kin-réseau, 24.7 in MoPoTsyo and 7.3 in FiLDCare, with a gradual decline over time (16).

Theoretical intervention model

The theoretical framework underlying the DSMS intervention is that the messages affect the knowledge and perceptions of patients, leading in turn to a change in self-management behaviour of and utilisation of care by individual patients. The theoretical pathway leading to

behaviour change was largely based upon the theory of planned behaviour. Messages were intended to target the behavioural, normative and control beliefs attached to each of the diabetes self-management behaviours (20,21). The self-management behaviours targeted were generic, but the beliefs that were addressed were specific for each context. Examples of the messages sent are: "Keeping diabetes under control is to protect your foot" (targeting behavioural beliefs), "*Un diabétique doit éviter de marcher pied nu*" (addressing normative beliefs), and "We are trying to understand and learn to manage diabetes by ourselves" (addressing control beliefs). Changing behavioural beliefs is expected to contribute to behaviour change, when the opportunity is there and there are no other obstacles. Changes in self-management and in the utilisation of care – which can be considered as intermediate outcomes - can then lead to improved health outcomes on the long term (figure 1). The framework also indicates other factors that can impact on and interfere with these pathways, such as personal and biomedical characteristics, the content of the routine programme and the wider context.

Figure 1. Framework depicting the interactions and pathways leading to health outcomes, person-related characteristics (personal, social, biomedical), context determinants (country), routine programme (biomedical care and DSME approach), utilisation of care, knowledge and self-management behaviour



Recruitment

Patients and staff from the participating centres in each programme were informed about the study and patients were invited to participate. In Kin-réseau and MoPoTsyo, enrolment was carried out in a serial way, during consecutive days planned for each participating centre. The randomisation system used a 4X4 randomised block design with the participant as unit of randomisation. Study code numbers and randomisation envelopes were prepared prior to enrolment. Persons willing to participate were subjected to an informed consent procedure. After signing the informed consent form, they were allocated to either trial arm. This procedure was led by the study team, independently from the routine programme staff. Randomisation was blinded, but the nature of the intervention led participants to know to which arm they belonged and educators usually learned this through the participants.

Measurements and measures

The variables for which data were collected relate to the three original research questions and to the characteristics of the participants and the routine programme (figure 1).

We report on personal characteristics (sex, age, education, age of onset, time since diagnosis, travel distance from educator and doctor), on health outcomes (HbA1c, BMI, waist circumference, waist-hip ratio, blood pressure, presence of foot wounds), on the routine programme (diabetes treatment, antihypertensive treatment and an adapted version of the Patient Assessment of Chronic Illness Care score (PACICc)(22), on utilisation of care (contacts with educator, health care expenditure), on patient knowledge & perceptions (diabetes knowledge, feeling of control, positive and negative attitude), on self-management behaviour (self-monitoring of glucose levels). The details about data collection are reported elsewhere (14).

Data were collected from 2012/2013 to 2014/15, during a face-to-face interview with a predefined questionnaire, physical examination and blood sampling (14). For each participant, data were collected at baseline (t1), year 1 (t3) and year 2 (t5). Additional efforts were made to contact participants who did not come for data collection, to retrieve them or to get information about the reasons of loss to follow-up. Those reasons were recorded in a database. Patients who died, stopped the study due to diabetes-related morbidity, migrated, refused further continuation or were lost to follow up for unknown reasons were not included in the analysis.

Sample size

The primary outcome measure on which the sample size calculation was based is the difference in the proportion of patients with a well-controlled HbA1c level (defined as HbA1C < 7.0% (53 mmol/mol)) after 2 years. The required sample size – 240 participants in each arm – in each country was based upon the following assumptions: 1) 60% of the participants had a well-controlled HbA1c level at the start, 2) a difference of 15% between the intervention and control group was considered relevant, with a 2-sided significance level of 5% with 80% power, 3) a 10% drop-out rate over the study period (14).

Analysis

Analyses of quantitative data was done with Stata version 11. A p-value of <0.05 was considered statistically significant for all tests. Continuous variables were tested for normality and non-normal distributions were categorised. Descriptive analyses were performed for all variables and unadjusted comparisons between study groups were made using T-tests (for continuous variables), Kruskall-Wallis test (for comparisons of medians) or Chi-square tests (for discrete variables). Data were analysed for confounding and interaction in multivariate regression analyses. We considered potential confounding effects of the following variables: HbA1c level at baseline (<7.0% vs => 7.0%), sex, education level (primary or less and secondary or more), age (<45/45-64/>64), time since diagnosis (<2years/2-4 years/5-9 years/>10 years), walking distance from educator (< =15 vs > 15 minutes), obesity at baseline (Body Mass Index (BMI) > 30: Y/N), unfavourable waist circumference at baseline (> 80 cm for females and > 94 cm for male in DR Congo and > 90 for men in Cambodia/Philippines (23), insulin treatment at the baseline (Y/N) and the number of SMS people that people remembered from the last month (>=10 vs <10). The choice for these variables was based upon earlier evidence about determinants of HbA1c (24), our theoretical framework and the bivariate analyses in our own dataset (p< 0.10). We started with a simple model, only including outcome (HbA1c status at the end), intervention and country (as three dummy variables). We added the other variables and kept the variable in the model if the OR altered substantially and if the difference between the 2 models was significant (p value of the likelihood ratio test <0.05). After the decision which variables to keep in the model, we checked these variables for interaction.

In addition to a multivariate logistic regression analysis, we analysed the change in HbA1c level over time, using longitudinal regression models. Hierarchical models were used to assess the influence of educator characteristics on the effects. We performed two secondary outcome analyses: firstly, the analysis of the difference in change over the 2-year study period in the percentage of people with a well-controlled HbA1C between intervention and control group (see figure 1) and secondly, an analysis of the individual change for each patient over 2 years time. Participants were categorised along their HbA1C level at baseline and after 2 years (<7.0% (53 mmol/mol), 7.0-7.9% (53-63 mmol/mol), 8.0-8.9% (64-74 mmol/mol), >9.0% (75 mmol/mol)). Those remaining in the same category were classified 'stable', those moving up one or more categories as deteriorating and those moving down as improving. We analysed the impact of the intervention through regression analysis.

We also analysed the effect of the intervention on other, secondary, outcomes and intermediate outcome variables, as indicated in the theoretical framework. Other health outcomes analysed were the change in BMI, waist circumference, waist-hip ratio, systolic and diastolic blood pressure and presence of foot wounds. Intermediate outcome variables were those related to the utilisation of care (change in number of contacts with the educator over the past year, direct medical and non-medical health expenditure), to knowledge and perceptions (change in number of correct answers in diabetes knowledge test, feeling of control and attitude towards diabetes) and to self-management behaviour (self-monitoring). To capture changes in the routine programme, we also analysed changes in medication regimens and in the adapted Perceived Assessment of Chronic Illness Care (PACIC). We checked the influence of potential confounding for the most relevant intermediate outcome variables (knowledge, positive and negative attitude, feeling of control, self-monitoring, contacts with the educator), through multivariate regression analyses, taking into account the same potential confounders as for the primary outcome.

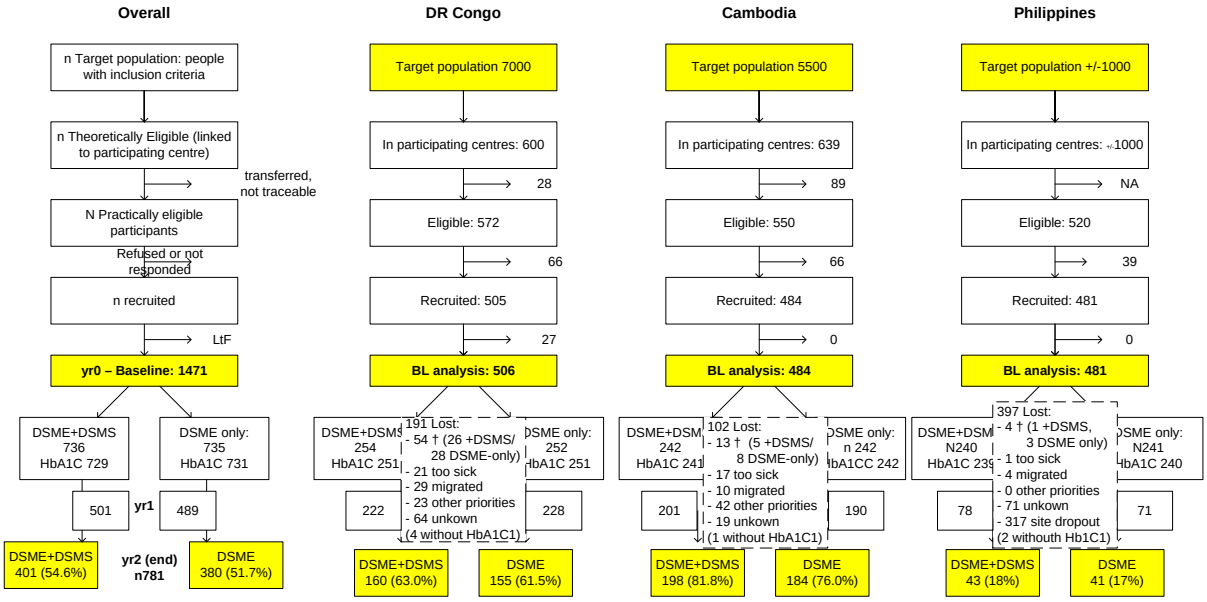
We did all analyses first at aggregate level for all patients together, adding the country as a dummy variable, and then for each country separately.

Results

Participants and baseline characteristics

In all there were 781 people for whom both the baseline and 2-year follow-up HbA1c measurements were available: 401 people in the intervention and 380 in the control group. Among these, there were 315 from Kin-réseau, 382 from MoPoTsyo and 84 from FildCare (figure 2). The reasons for the high Loss To Follow-Up (LTFU) rate in FildCare were largely related to the discontinuation of the study in the largest of the three field sites, with 317 participants. The LTFU among participants in the two other field sites in FildCare was comparable to the LTFU in Kin-réseau and MoPoTsyo. The LTFU due to death was larger in Kin-réseau (11%) than in the other programmes (3% and 1%). For 20 cases in DRC, the cause of death was recorded, 3 of which were directly caused by diabetes, the others varying from cerebrovascular accidents, over infectious diseases to 'old age'. An overview of the differences in main characteristics between the participants and those LTFU is available as web annex 1 (table 1). Apart from the difference in education level (higher LTFU among higher educated, accounted for by the differences in the FiLDCare programme), none of the other differences were significant. A full overview of the baseline characteristics of the study participants, the characteristics of care, physical outcomes, perceptions of care and self-management, is provided in another paper (15). The dataset with data for all participants is available online (web annex 2).

Figure 2. Flow-chart of study participants ('theoretical eligibility' refers to being registered as patient in a participating centre, 'practical eligibility' refers to regular attendance over the last year)



Effect of the intervention

After 2 years, the proportion of people with a HbA1c <7.0% (53 mmol/mol, 'controlled diabetes') was 2.8 percentage points higher in the intervention group than in the control group (33.9% vs 31.1%) (table 1, aggregate analysis). This difference was not statistically significant (p=0.39).

In the final logistic regression model, the OR of the intervention for having a controlled diabetes is 1.1 (95% CI 0.8-1.6), corrected for diabetes control status at start, for sex, for being on insulin treatment and for the routine programme. Testing for interaction of these variables did not improve the predictive value of the model and was ignored. A cluster effect at educator level was not present. (web annex, figure 2)

We then performed a longitudinal analysis, in which we tested the influence of intervention, country and time (3 time points, baseline, 1 year and 2 years) on the chance of being controlled after 2 years. The best predicting temporal model has a random intercept and an interaction term for intervention, time and country. The interaction shows that there is a non-significant time-effect of the intervention in the three programmes (web annex, figure 3).

Table 1. Overview of the primary outcome measure % of people with controlled diabetes after 2 years and of the secondary outcome measure difference in change between start and end, between intervention and control group

	OVERALL			Kin-réseau			MoPoTsyo			FildCare		
	DSME+DSMS (S)	DSME-only (E)	p, H0: ΔS=ΔE	DSME+DSMS (S)	DSME-only (E)	p, H0: ΔS=ΔE	DSME+DSMS (S)	DSME-only	p, H0: ΔS=ΔE	DSME+DSMS (S)	DSME-only (E)	p, H0: ΔS=ΔE
% of people being controlled at end (< 7.0%)	33.9%	31.2%	0.39	29.4%	21.9%	13.0%	35.4%	37.5%	0.66	44.2%	36.6%	48.0%
change of % of people with controlled diabetes (p H0: Δ=0)	-1.7%, p=0.60	-3.6%, p=0.28	0.09	+4.4%, p=0.38	+0.6%, p=0.89	0.04*	-9.1%, p=0.06	-7.1%, p=0.17	0.47	+9.3%, p=0.38	-4.9%, p=0.65	0.43

Development of HbA1C over 2 years

The secondary outcome that provides information about the development of HbA1C over time at group level is the difference in change in proportion of patients with a controlled diabetes from baseline between the intervention and the control group (Table 2). There were differences between the programmes. In Kin-réseau, the increase in people with controlled diabetes was significantly larger in the intervention than in the control group (4.4% vs 0.6%, p=0.04). In MoPoTsyo, there was a decrease of people with controlled diabetes. In FilDCare, diabetes control seems to improve in the intervention group and to decrease in the control group, although the remaining sample size is too small to demonstrate statistically significant differences.

The analysis of the development of HbA1C for individual participants, along HbA1C level categories (<7.0%, 7.0-7.9%, 8.0-8.9%, >9.0%) revealed that the majority of people don't change from HbA1c-category over 2 years' time (web annex, figure 4). In the control group, a larger proportion of people (59.7%) remained in the same HbA1c category than in the intervention group (50.6%). This difference was significant only in Kin-réseau (66.5% vs 51.3%, p=0.01). The proportion of people improving at least one category is larger in the intervention than in the control group (20.9% vs 15.5%, p=0.05 in the aggregate analysis) (web annex, table 3).

In the logistic regression model, the OR of the intervention for improving at least one category is 1.4 (0.9-2.0, p=0.10), corrected for the time since diagnosis, for remembering at least 50% of the DSMS and for the country routine programme. Testing for interaction of these variables did not improve the predictive value of the model and was ignored. A cluster effect at educator level was not present. (web annex, fig 4).

Other outcomes

There was a significant difference in decrease in the number of people with foot wounds in the intervention group compared to the control group. The intervention did not significantly alter the other health outcomes, also not when controlled for potential confounding factors. For some secondary health outcomes, a significant change over time was observed, similar for both intervention and control groups. This was the case for waist circumference, which increased, and for diastolic Blood Pressure (BP), which decreased in all countries.

The intervention did not appear to have an effect on intermediate outcome indicators such as patient knowledge, perceptions and their utilisation of care (table 2). Some indicators showed a change over time, which was similar for participants of both intervention and control groups. For instance, all participants in MoPoTsyo and FildCare dropped their attendance rates with the educator. The negative attitude towards diabetes decreased for all participants from Kin-réseau and FiLDCare over time. In MoPoTsyo, there was a significant decrease in the number of people self-monitoring glucose levels, in both intervention and control group.

Table 2 also shows that there were changes in the diabetes management in the routine programme. In Kin-réseau, there was a 20% increase in participants on insulin, in both the intervention and control groups. In Kin-réseau and MoPoTsyo, more people received antihypertensive treatment, the increase among people in the intervention group being larger than in the control group. In all programmes, the PACICc score went down. (Table 4)

Table 2. Change in health outcomes from begin to end, for intervention and control groups (pp = percentage point, headings refer to the theoretical framework, figure 1)

	OVERALL			Kin-réseau			MoPoTsyo			FildCare		
	DSME+DSMS (S)	DSME-only (E)	p, H0: ΔS=ΔE	DSME+DSMS (S)	DSME-only (E)	p, H0: ΔS=ΔE	DSME+DSMS (S)	DSME-only (E)	p, H0: ΔS=ΔE	DSME+DSMS (S)	DSME-only (E)	p, H0: ΔS=ΔE
	p(H0:start=end)	p(H0:start=end)		p(H0:start=end)	p(H0:start=end)		p(H0:start=end)	p(H0:start=end)		p(H0:start=end)	p(H0:start=end)	
Other health outcomes												
change in bmi, mean ± sd	+0.0 ± 1.9, p=0.92	+0.0 ± 2.4, p=0.82	0.94	+0.3 ± 2.0, p=0.85	+0.3 ± 2.7, p=0.91	0.93	-0.1 ± 1.2, p=0.70	-0.2 ± 1.6, p=0.48	0.51	-0.1 ± 3.7, p=0.87	+0.3 ± 4.1, p=0.85	0.61
change in waist circumference, mean ± sd	+3 ± 8, p=0.00*	+2 ± 8, p=0.00*	0.22	+4 ± 9, p=0.00*	+3 ± 9, p=0.01*	0.38	+2 ± 5, p=0.07	+1 ± 5, p=0.14	0.37	+6 ± 12, p=0.02	+4 ± 15, p=0.11	0.66
change waist hip ratio, mean ± sd	0.00 ± 0.08, p=0.39	0.00 ± 0.10, p=0.22	0.70	0.00 ± 0.10	0.00 ± 0.13	0.90	+0.01 ± 0.05	+0.01 ± 0.05	0.54	+0.01 ± 0.08	+0.01 ± 0.12	0.98
change in systolic bloodpressure mean ± sd	+1 ± 24, p=0.03*	+2 ± 26, p=0.00*	0.58	0 ± 27, p=0.99	+2 ± 30, p=0.57	0.52	+5 ± 17, p=0.01*	+5 ± 18, p=0.02*	0.89	-9 ± 32, p=0.14	-7 ± 33, p=0.24	0.73
change in diastolic bloodpressure	-4 ± 14, p=0.00*	-3 ± 13, p=0.00*	0.49	-4 ± 16, p=0.03*	-3 ± 15, p=0.04*	0.78	-2 ± 10, p=0.02*	-2 ± 10, p=0.01*	0.94	-10 ± 19, p=0.00*	-5 ± 17, p=0.11	0.24
change in people with foot wound, pp	-3.5%, p=0.02*	-1.3%, p=0.38	0.05	-9.0%, p=0.01	-3.9%, p=0.21	0.08	+0.5%, p=0.65	+0.5%, p=0.65	0.96	-2.3%, p=0.64	0.0%, p=1	0.33
Utilisation of care												
change in number of contacts with educator (last year), median (IQR)	-2 (-9;+2), p=0.00*	-2 (-9;+2), p=0.00*	0.68	0 (-8;+6), p=0.96	0 (-12;+4), p=0.98	0.76	-4 (-9;0), p=0.00*	-3 (-9;0), p=0.00*	0.52	-2 (-8;0), p=0.00*	-1 (-3;0), p=0.00*	0.28
change in direct health expenditure (USD), median (IQR)	+0.50 (-3.14;+4.31), p=0.39	+0.25 (-3.81;+3.52), p=0.04*	0.23	-0.76 (-6.83;7.02), p=0.45	-2.01 (-8.17;+3.81), p=0.01*	0.19	+0.75 (-0.88;+3.02), p=0.00*	+0.75 (-0.63;+3.02), p=0.06	0.78	-11.59 (-23.18;+44.83), p=0.00*	-11.59 (-42.88;+40.56), p=0.00*	0.45
change in direct non-medical health expenditure, median (IQR)	0 (-3.27;+1.76), p=0.39	0 (-3.27;+1.51), p=0.01*	0.85	-7.08 (-47.92;3.22), p=0.25	-6.29 (-38.06;3.81), p=0.87	0.65	0 (-1.26;+1.26), p=0.43	0 (-1.26;+1.26), p=0.01	0.62	0.00 (-8.11;+0.00) (n=10)	-9.73 (-16.22;-8.81) (n=7)	0.01*
Intermediate output: patient knowledge & perceptions												
change in correct diab knowledge, mean	+0.3±4.0, p=0.16	+0.7±4.3,p=0.00*	0.24	+0.3±5.2 p=0.53	+0.4±4.3, p=0.33	0.77	+1.0 ± 2.92, p=0.00*	+1.4 ± 2.98, p=0.00*	0.25	-2.7 ± 5.2, p=0.00*	-1.4 ± 6.1, p=0.11*	0.32
change in feeling of control, mean	0.3±3.2, p=0.35	+0.2±3.4, p=0.46	0.8	-0.2±3.4, p=0.36	-0.7±3.0, p=0.06	0.27	0.3 ± 2.6, p=0.31	+0.1 ± 2.9, p=0.70	0.63	+2.0 ± 4.7, p=0.00*	+3.6 ± 4.5, p=0.00*	0.11
change in positive attitude, mean	+0.3±3.8, p=0.11	0.0±4.1, p=0.94	0.24	+0.3±4.2, p=0.48	-0.5±4.3, p=0.14	0.11	-0.1 ± 3.1, p=0.63	0 ± 3.5, p=0.95	0.74	+2.5 ± 4.5, p=0.00*	1.8 ± 5.1, p=0.02*	0.49
change in negative attitude, mean	-1.8±6.4, p=0.00*	-1.3±6.5, p=0.00*	0.32	-3.1±6.3, p=0.00*	-2.1±6.2, p=0.00*	0.2	+0.2 ± 5.6, p=0.65	+0.7 ± 5.7, p=0.13	0.38	-6.6 ± 6.5, p=0.00*	-7.1 ± 6.7, p=0.00*	0.78
Intermediate output: self-management behaviour												
change in people self-monitoring, pp	-15.0%, p=0.00*	-10.4%, p=0.00*	0.06	+3.4%, p=0.50	+5.5%, p=0.27	0.37	-31.3%, p=0.00*	-28.3%, p=0.00*	0.51	-8.7%, p=0.38	+9.2%, p=0.38	0.94
Indicators about the routine programme												
change in people on insulin treatment, pp	+7.4%, p=0.01*	+11.2%, p=0.00*	0.09	+20.3%, p=0.00*	+18.6%, p=0.00*	0.73	+0.2%, p=0.93	+6.7, p=0.06	0.00*	1.4%, p=0.84	+2.5%, p=0.69	0.72
change in people on antihypertensive treatment, pp	+15.8%, p=0.00*	+10.4%, p=0.00*	0.03*	+22.2%, p=0.00*	+13.9%, p=0.02*	0.08	+16.3%, p=0.00*	+8.0%, p=0.13	0.02*	-10.5%, p=0.29	+8.8%, p=0.43	0.19
change in PACIC, mean	-6.3±12.8, p=0.00*	-6.3±18.8, p=0.00*	0.98	-2.6±12.8, p=0.01*	-1.8±12.2, p=0.07	0.56	-7.2 ± 10.5, p=0.00*	-7.8 ± 11.8, p=0.00*	0.59	-15.1 ± 18.0, p=0.00*	16.2 ± 21.5, p=0.00*	0.8

Discussion

Summary of findings

We were not able to demonstrate that the DSMS intervention led to more people with controlled diabetes after 2 years. The multivariate regression analyses show that the most important determinant for having controlled diabetes after 2 years is having a controlled diabetes at baseline. This is in line with the analysis of HbA1c for individual participants, which shows that more than half of the participants remained in the same HbA1c category. Considering the fact that diabetes is a progressive disease, it is a rather good sign that the vast majority of patients remains at least stable over a 2 years' period.

The general tendencies in HbA1c dynamics over time were different between programmes, with the number of people having controlled diabetes increasing in Kin-réseau for all participants and decreasing in MoPoTsyo. The favourable development in Kin-réseau was significantly larger for the group with the additional DSMS intervention. This is in line with the finding that there is less occurrence of a late complication, namely foot wounds, among patients in the DSMS group in Kin-réseau. Foot wounds were relatively frequent among Kin-réseau participants at the start. Soon after, attention for and access to foot care was improved in the routine programme. The additional effect among participants in the DSMS intervention could point to text messages as an additional motivator.

There were no significant effects of the intervention on the intermediate outcomes and on other outcomes. If changes in intermediate outcomes were present, they were observed in both the intervention and control groups. The decrease in negative attitude towards diabetes in Kin-réseau and FilDCare was remarkable. With increasing attention for the linkages between negative emotions and diabetes control, we perceive this as an important finding.

The pharmaceutical management within the Kin-réseau and MoPoTsyo programme has been intensified, with more people receiving insulin and anti-hypertension treatment. The larger increase among people in the intervention group suggests that the messages may have pushed this development.

Although the baseline characteristics of the participants in the MoPoTsyo program were better than those of the other programs, many indicators for participants in this program worsened over the study period. The explanations for this deterioration might be looked for in the changes in the routine programme. Striking is the reduction in the frequency of contacts with the educator and in the percentage of people performing glucose monitoring. An explanation for the change might be related to the scaling up of the routine MoPoTsyo programme within the national strategy, which has led to uncertainty among staff and patients and delays in payments, decreasing motivation of peer educators (25).

Limitations

The limitations of our study relate to the design and rate of LTFU, the implementation of the intervention, and the tools used for data collection.

The LTFU was larger than anticipated and different in each programme. Apart from being higher educated, there were no apparent differences in baseline characteristics between those LTFU and those remaining, but some of the people LTFU died or were too sick, implying that these were people with worse health outcomes. Since the number of people LTFU was comparable between intervention and control group, this is not expected to have influenced the estimated intervention effects. The particular LTFU in FildCare, linked to the complete drop-out of the largest study site, makes it difficult to interpret findings from this programme. The LTFU from the two remaining FildCare study sites was comparable to the LTFU in the other 2

programmes, both in numbers and in causes. The differences in FU justify a separate analysis for each programme, which was also foreseen in the original sample size calculation.

The anticipated risk of contamination between the intervention and control group, through patients of both groups being in contact, turned out to be real (14). Programme managers and educators reported that patients exchanged messages among each other. An additional contamination effect has probably come from educators, who were aware of the content of DSMS text messaging and incorporated similar content into their routine DSME, which reached both groups. In Kinshasa, patients visited the educator to ask additional questions, thereby contributing to improved interaction. This can also be regarded as a (welcome) strengthening of the routine programme.

The implementation of the intervention was more problematic than foreseen. Technological barriers limited the possibilities of targeting messages and of reaching participants. The commercialisation of the SMS market resulted in people being overwhelmed with messages leading to a certain lethargy in reading them. The need to develop and send messages regularly required organisational capacity, which varied across programmes leading to differences in effective coverage across the 3 programmes (16). The coverage was best in Kin-réseau, with more than half of the patients remembering the receipt of most messages. A better coverage seems to be linked to better results.

Although we used a theoretical framework in the design of the intervention, there was fewer emphasis on its application in the operationalisation and on the measurement of changes of the intermediate outcomes. It was difficult for the country teams to target behavioural beliefs in the texts of the messages. The suboptimal application of the behaviour theory principles throughout the implementation phase can have decreased the potential of the messages. In the data collection, we did not use instruments to measure the change in behavioural beliefs. Instead, we used a number of scales from the Diabetes Care Profile, which measure overarching concepts such as the feeling of control and the attitude towards diabetes. These scales were not locally validated. The homogenous scores for most scales made these instruments of limited value to detect differences between contexts or over time.

Our study in a larger perspective

Two meta-analyses report mixed effects of mobile phone interventions and automated text messages on glycaemic control in type 2 diabetes patients (10,13). A number of studies in developing countries demonstrated a positive impact of SMS on HbA1C (26,27). Most studies lasted 6 months to maximum 1 year, in contrast to our study. In our study, we had a wide variety of patients (e.g. diabetes duration, antidiabetic therapy), while in many other studies, the selection led to more homogenous cohorts, for instance only patients on oral treatment (26). Some studies combined SMS with other tools (28). Only few studies report on intermediate outcomes, thus it is difficult to unravel the mechanisms of change (10).

The SMS in our study had been conceptualised as behavioural support, for which other studies proved some evidence (29). However, if the messages sent out were not perceived as such, this would have affected their potential (30). Our theory of change stated that DSMS works through the mechanism of increased knowledge and perceptions of patients. The absence of measurable changes in these indicators could therefore explain the absence of effect on final outcomes. It is also possible that other unrevealed covariates interfered in the relationship between intervention and HbA1c. Personal and disease-related characteristics of the patient, and of the routine care, could be more determining for health outcomes. Our study was done in three different programmes, in which participants had different characteristics and health indicators at baseline. Although we know HbA1C to gradually increase over time, with an average of roughly 1% (10.9 mmol/mol) over two years, it is less clear how the duration of disease, quality of care and different phenotypes of diabetes impact on this trend (31).

Another explanation for the absence of an effect might be that any potential effect of the DSMS intervention might have been realised, not through the mechanism of increased knowledge or better coping skills, but through patients receiving improved care, such as more people being put on insulin or better routine care education. The fact that similar studies show a positive effect on HbA1c without a substantial change in behaviour also suggests the influence of other pathways (32). These effects would then naturally spill over into the control group. The only programme in which the intervention showed a marginal effect – additional to an overall improvement – was Kin-réseau.

Lessons learnt from our research relate to the design and implementation, to the extent of diabetes control in programmes in LMIC and to the expected effect of mhealth. The integration of a long-term health intervention into a diabetes care and self-management programme requires quite an organisational capacity. There is a substantial risk for LTFU due to death, migration and people having other priorities. Since this loss is not only relevant for research, but also for the organisation of health care and self-management programmes for people with chronic life-long conditions in general, it is important to better understand the reasons for LTFU and to address them. The health outcomes of participants are largely determined by personal and disease-related characteristics and by the content of care and approach to chronic illness and self-management of the programme. The potential effect of a simple mhealth intervention like sending SMS on diabetes control is marginal to the other factors. While mhealth can be a tool for health providers for reaching out to patients, it might be even more interesting to examine mechanisms to increase mutual connectivity between patients, providers and their support systems.

Conclusions

To our knowledge, this is the first study which reports the results of a randomised controlled trial testing a similar mhealth intervention for diabetes control in 3 different LMIC, thereby contributing to the domain of translational research. It is also a rare study with a long-term follow-up of 2 years. While other studies show a potential positive effect of SMS messages added to a routine care and self-management programme, we were not able to confirm this. The reasons for the absence of this effect can be related to the variety of patients and disease-related characteristics, to the implementation of the intervention and to the influence of the routine programme on the outcomes. A detailed analysis of the content of messages and of the perceptions of patients about both the (changes in) the routine programme and the DSMS intervention will contribute to a better understanding of why the intervention did not work as expected and to further unravel the mechanisms of potential change.

Annex

Figure 1. Study design with the primary and secondary outcome measure indicated

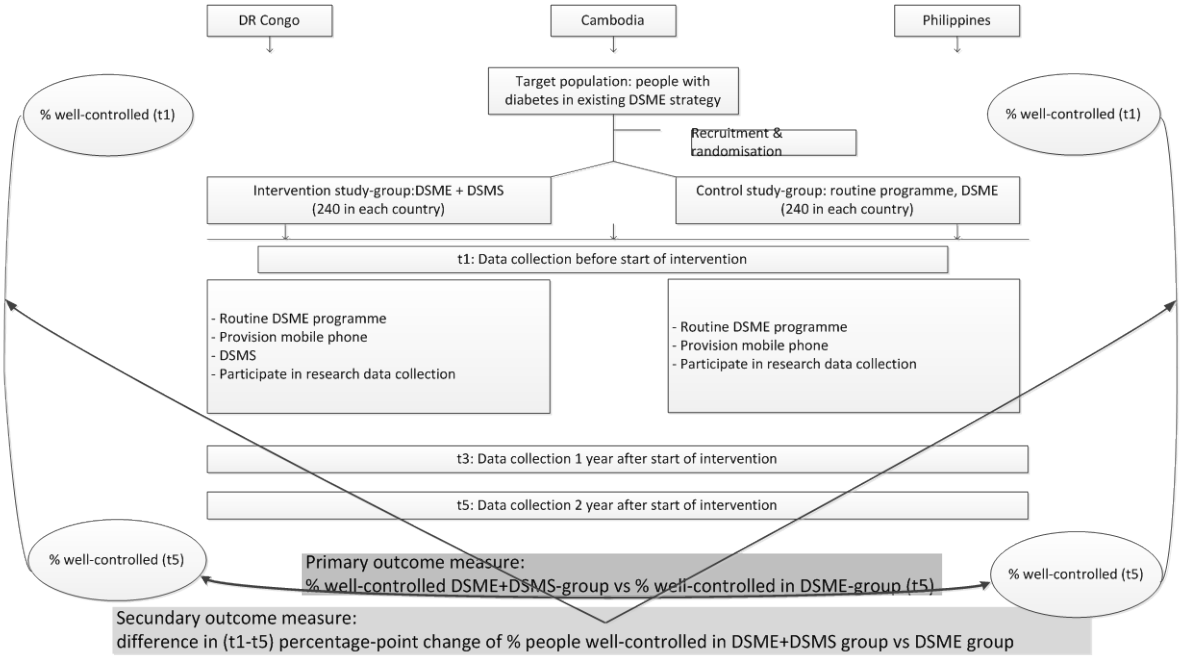


Table 1. Differences of baseline characteristics between those remained and lost to follow-up (*p<0.05)

	Overall (n 1471)		**Kin-Réseau (n 506)**		**MoPoTsyo (n 484)**		**FildCare (n 481)**	
	n in FU (781)	n LTFU (690)	n in FU (315)	n LTFU (191)	n in FU (382)	n LTFU (102)	n in FU (84)	n LTFU (397)
sex (male), %	29	37	33	33	33	28	21	41
age (mean ± sd)	58 ± 10	60 ± 10	59 ± 10	63 ± 11	55 ± 9	60 ± 12	59 ± 11	63 ± 9
education primary only or less, %	50*	26	48	51	58	58	22*	7
time since diagnosis, med (IQR)	4 (2-8)	6 (3-12)	6 (3-10)	7 (3-7)	4 (2-7)	4 (2-7)	4 (2-10)	7 (3-13)
travel distance from educator (hour)	0.25	0.33	0.42	0.5	0.25	0.29	0.14	0.25
HbA1C at start (%, mean ± sd)	8.2 ± 2.1	8.4 ± 2.3	8.8±2.3	9.1±2.4	7.5±1.7	7.7±2.0	8.6±2.7	8.2±2.3
% of people with a HbA1C < 7.0% at start	35.1%	34.5%	23.2%	22.0%	44.5%	39.6%	38.1%	39.0%
treatment with insulin, %	24%	22%	49%	59%	8%	11%	9%	6%

Table 2. Factors related to controlled diabetes after 2 years (HbA1c < 7.0%) (multivariate multilevel logistic regression analysis [xtlogit in Stata], adjusted for clustering in 26 diabetes educator groups (5 in Kin-Réseau, 9 in MoPoTsyo and 12 in FildCare))

	Odds Ratio (95% CI)
Intervention	1.12 (0.78-1.59)
Baseline HbA1c < 7.0	8.32 (5.72-12.12)
MoPoTsyo (reference: Kin-Réseau)	0.80 (0.48-1.34)
FildCare (reference: Kin-Réseau)	1.32 (0.65-2.66)
Insulin treatment	0.43 (0.25-0.73)
Sex (male)	0.65 (0.44-0.95)

Estimated variance of error: 0.27
IntraClass Correlation (ICC) 0.022
Likelihood-ratio ICC=0: chibar2(01)= 1.67 Prob >=Chibar2=0.098

Table 3. Factors related to controlled diabetes (HbA1c < 7.0%) (temporal logistic regression analysis [xtmelogit in Stata], with 3 time-points for 781 participants with interaction between country, time and interventions)

		Odds Ratio (95% CI)
Time		1.02 (0.83-1.27)
MoPoTsyo (reference: Kin-Réseau)		19.07 (5.32-68.37)
FildCare (reference: Kin-Réseau)		12.08 (1.76-82.85)
Interaction term: country-time (reference: Kin-Réseau)		
	MoPoTsyo	0.82 (0.63-1.08)
	FildCare	0.86 (0.57-1.30)
Intervention		1.52 (0.40-5.84)
Interaction term: intervention-time		1.12 (0.84-1.51)
Interaction term: country – intervention (reference: Kin-Réseau)		
	MoPoTsyo	0.65 (0.12-3.56)
	FildCare	0.42 (0.03-5.85)
Interaction term: country – intervention – time (reference: Kin-Réseau)		
	MoPoTsyo	0.85 (0.59-1.23)
	FildCare	1.23 (0.71-2.14)

ICC: ~1

Likelihood-ratio test vs. Log regression chibar2(01)=558.90 Prob>=chibar2=0.000

Figure 2. Grouping of patients according to their baseline and end HbA1C (n 781)

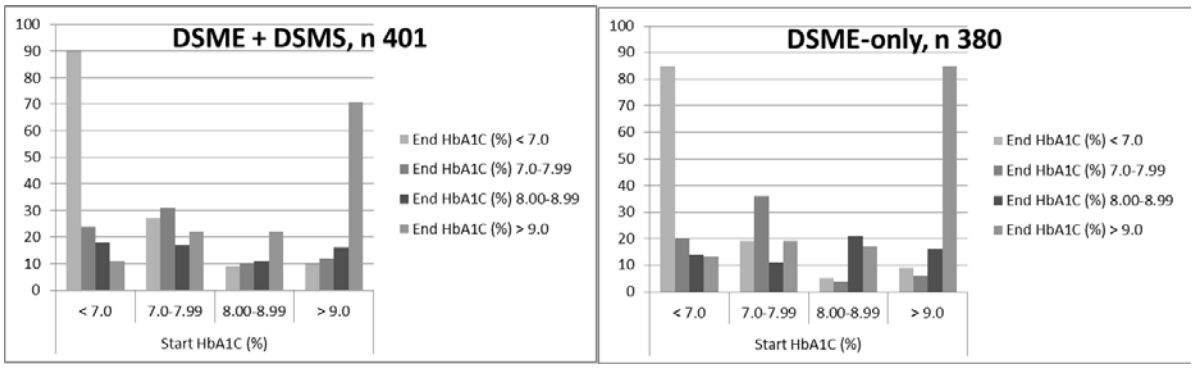


Table 4. Overview of individual development of HbA1C over time for people from intervention and control group

Aggregate	**DSME + DSMS**		**DSME only**		p
Remaining same category	203	50.6%	227	59.7%	0.01*
Improving category	84	20.9%	59	15.5%	0.05*
Deteriorating category	114	28.4%	94	24.7%	0.24
Kin-réseau					
Remaining same category	82	51.3%	103	66.5%	0.01*
Improving category	41	25.6%	27	17.4%	0.08
Deteriorating category	37	23.1%	25	16.1%	0.12
MoPoTsyo					
Remaining same category	99	50.0%	99	53.8%	0.46
Improving category	32	16.2%	24	13.0%	0.38
Deteriorating category	67	33.8%	61	33.2%	0.89
FildCare					
Remaining same category	22	51.2%	25	61.0%	0.36
Improving category	11	25.6%	8	19.5%	0.5
Deteriorating category	10	23.3%	8	19.5%	0.68

Table 5. Logistic regression for 'Improving HbA1C at least 1 category from start to end (multivariate multilevel logistic regression analysis [xtlogit in Stata], adjusted for clustering in 26 diabetes educator groups (5 in Kin-Réseau, 9 in MoPoTsyo and 12 in FildCare)

	Odds Ratio(95% CI)
Intervention	1.34 (0.91-1.97)
MoPoTsyo	0.64 (0.43-0.97)
FildCare	1.32 (0.71-2.43)
Time since diagnosis	1.58 (1.07-2.34)
Number of DSMS received	1.74 (1.13-2.67)

Estimated variance of error: 0.01
ICC < 0.001
Likelihood-ratio ICC = 0: chibar2(01)= 5.1e-05 Prob >=Chobar2=0.497

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